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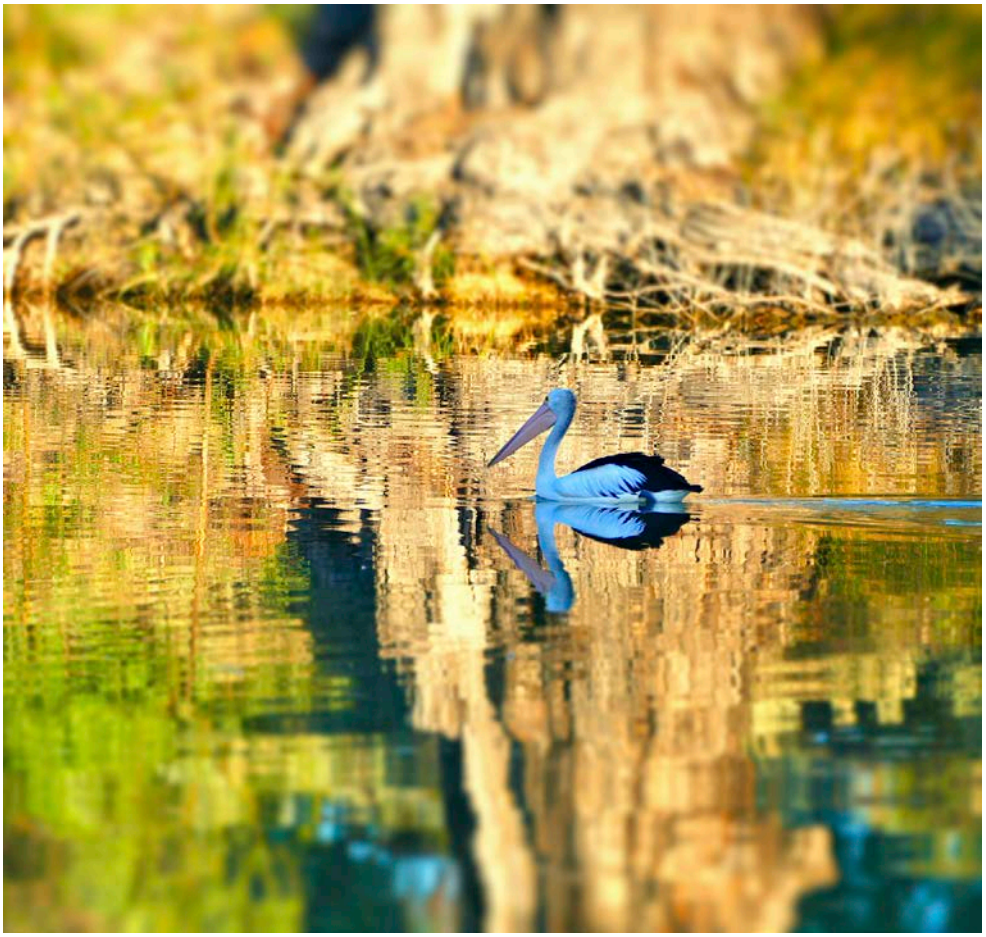
Managing Water for the Environment During Drought

Lessons from Victoria, Australia



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Over the past 30 years the Australian state of Victoria developed innovative approaches to planning and setting priorities for environmental water, along with new tools to manage it. These sweeping reforms were in part a response to the Millennium Drought, a decade-long record dry spell that severely affected all water use in Victoria. California—currently in its fifth year of drought—has many similarities with Victoria, including significant challenges in managing the health of rivers and wetlands during times of extreme water scarcity. In this report, we examine the reforms enacted by Victoria and compare them to current environmental water management policies in California. This comparison highlights some key lessons learned by Victoria that may help guide how California adapts environmental water management to address future droughts.

The environmental policy reforms enacted by Victoria were difficult and at times highly controversial. While it will take years to fully understand whether these reforms had their intended effect, there is no doubt that the state's new approach to managing environmental water avoided some serious biological losses during the drought. Additionally, it is clear that the state is much better prepared for the next drought.

Four general lessons could be of high value to California:

1. **Better planning prior to droughts** can improve drought resilience of native species and reduce conflicts.
2. **Strong federal-state partnerships**—involving both policies and funding—are vital to reducing drought impacts.
3. **Granting the environment a water right** that can be traded improves flexibility in environmental water management during drought.
4. **Integrating the environment** as an equal priority to other water uses improves drought preparation and response.

Much more needs to be done to improve the drought resilience of California's freshwater ecosystems. The efforts of Victoria can offer a useful guide in this effort.

Introduction

From 1997-2010, Australia endured the driest period in its recorded history. Known as the "Millennium Drought," it tested the country's water management systems and caused an unprecedented restriction of supplies for cities and farms as well as cuts in water needed to support the environment (van Dijk et al. 2013). Australia's response to this drought—involving major reforms in water policy, new planning approaches, and development of extensive new infrastructure—is often held up as a model for managing periodic droughts in California (Patterson 2015). When looking at Australia as an example, most attention has been focused on how its water managers allocated supplies to meet urban and agricultural needs (Turner et al. 2016). However, there has been equally important innovation in prioritizing and delivering water for Australia's environment during drought.

California's latest drought, with five consecutive years of dry and warm conditions, has left no sector untouched (Hanak et al. 2015, Mount et al. 2015a).[1] California's rivers and wetlands have been hit particularly hard. State and federal fish and wildlife managers have struggled to prevent extinction of many native fishes, including most of the state's runs of salmon. They have also had to make tough choices about allocations of water for managed wetlands that are vital to migratory waterbirds of the Pacific Flyway. The difficulties faced by environmental managers in Australia during the height of the Millennium Drought are similar to those currently facing California.

Over the past 30 years the Australian state of Victoria (Figure 1), along with the federal government (called the Commonwealth), developed innovative approaches to planning and setting priorities for environmental water, along with new tools to manage it. Many of these efforts improved transparency and reduced conflict, which increased management effectiveness. Implementation of these policies and approaches was not easy, but they left Victoria significantly better prepared for the next drought. In this report, we examine Victoria's response to extreme drought, focusing on the development of policies for managing environmental water. We compare these policies to those of California. This comparison highlights some key lessons learned by Victoria that may help guide how California adapts environmental water management to address future droughts.

FIGURE 1
The Murray-Darling Basin and Victoria, Australia

SOURCE: Modified from the Murray-Darling Basin Authority
NOTE: The Murray-Darling Basin is
The Murray River defines the northern border of Victoria. Most reservoir storage in Victoria—along with water use for agriculture—occurs on tributaries to the Murray River.

Two technical appendices supplement this report. Appendix A is a comprehensive review of environmental water management in Victoria. Appendix B summarizes the laws governing the allocation of water in Victoria and California.

[1] At the time of this writing (spring 2016) northern California had received near-average precipitation during water year 2015-16, while southern California remains dry. A gubernatorial emergency drought declaration remains in effect.

Victoria's Approach to Environmental Drought Management

Drought is common in both Victoria and California. Since statehood, both states have developed a system of institutions, laws and infrastructure to manage episodic water scarcity. Victoria, like California today, recently endured the most severe drought in its recorded history, including 10 consecutive years of dry conditions. For both states, severe drought revealed strengths and weaknesses in water planning and drought management, particularly in efforts to reduce harm to freshwater ecosystems. It is useful for California to examine how Victoria's drought management changed, including reforms that occurred before the drought that set the stage for a more comprehensive overhaul.

Before the Millennium Drought, the Commonwealth and the five states of the Murray-Darling Basin (MDB) undertook substantial reform of their water allocation laws and institutions. These reforms were a response to decreasing water supply reliability, a decline in environmental conditions, and a shift in national policy toward sustainable water management. These changes were embodied in the Victorian Water Act of 1989 (see Technical Appendix B).

The Millennium Drought tested these early reforms as consecutive years of record dryness led to unprecedented reductions in available supplies. The environmental effects of drought were vast, reducing riparian, floodplain, wetland, and lake species, including iconic trees, such as the river red gum, and many species of birds and fish (van Djik et al. 2013, Ellis et al. 2013). Due to water and land management activities before the drought, many of these species had already experienced significant population declines. The drought, with exceptionally dry and warm conditions and competing demands for scarce water, eliminated the river flows needed to support these species, increasing the risk of extinction.

At the height of the Millennium Drought, Victoria implemented a series of policies and subsequent amendments to the Water Act (Victoria DELWP 2016). These amendments enhanced the capacity of Victoria, in partnership with the Commonwealth, to more effectively manage limited supplies for the environment and balance uses for cities and farms with water for ecosystems.

Here we focus on two main reforms in Victoria's environmental water management that provide the most pertinent lessons for California: building and managing an environmental water portfolio, and drought planning and priority setting.

The Environmental Water Portfolio

The landmark Water Act of 1989 restructured Victoria's water rights system and significantly enhanced the protection of fish, wildlife, and wetlands within the new "water entitlement" structure. The act recognized that the environment is a lawful user of water with rights that are equal in stature to those that support other uses, such as municipal water supply and irrigation (see Technical Appendix B). Since that time, the state, in partnership with the Commonwealth and through several amendments to the original act, has built a water portfolio that it can use to meet environmental objectives.

Victoria has authority under the act to allocate surface and groundwater through a set of water entitlements and shares that allow for the storage and distribution of water for municipal, agricultural, and environmental uses. The Victorian Environmental Water Reserve (VEWR) is the principal means by which Victoria allocates water to meet environmental objectives. VEWR assets that are critical for drought management include "planned

environmental water" and "held environmental water."[2] (See Figure 2 for an illustration of the timing of use of these assets.)

The VEWR program is funded through a volume-based environmental fee charged to agricultural and urban water users. These monies are for sustainable water use projects as well as projects that reduce the environmental impacts of water use. A portion of these fees help cover the costs of the VEWR program, including administration, monitoring, scientific support for management, purchasing water shares, and managing habitat.[3] A relatively small amount of revenue also comes from leasing environmental water to other users. In addition, during and after the Millennium Drought, the Commonwealth provided more than AU$3 billion (around US$2.3 billion at current exchange rates) for the purchase of environmental entitlements (i.e., water rights for the environment) to support environmental objectives throughout the MDB. These purchases have grown substantially since the end of the Millennium Drought, exceeding more than two million acre-feet today.[4]

Planned Environmental Water

The Water Act of 1989 set minimum flow requirements in all of Victoria's major river basins for different hydrologic conditions. These standards require that "planned environmental water" (also called "passing flows") remains in rivers to fulfill a range of objectives, including providing environmental protection and water supply for downstream users. A portion of the water retained in storage for urban and agricultural uses is set aside to meet these minimum flow requirements. This water must be released from storage or provided at a specific place on a river. In rivers without reservoir storage, planned environmental water is created by limiting the timing and amount of surface diversions (see text box).

During severe drought, planned environmental water can be reduced to ensure that critical water supply needs are met, usually for urban users. The reduction in planned environmental water is referred to as a "qualification of rights." The Victorian Minister of Water has authority to temporarily change planned environmental water requirements. In order to qualify a right, the minister will sometimes require mitigation measures, including payments to the Ministry to help compensate for harm to the environment (see Technical Appendix A).

Held Environmental Water

In 2005, Victoria amended its Water Act to expressly recognize environmental water entitlements (or rights).[5] In basins regulated by reservoirs, this "held environmental water" is reserved for environmental purposes. In 2010 Victoria again amended the act to establish the Victorian Environmental Water Holder with the authority to manage all held environmental water, planned environmental water, and water acquired through temporary trades (Victorian EWH 2016).[6] The VEWH has considerable discretion to determine how, where, and when water from environmental entitlements can be used. For example, it can choose to augment planned environmental water using held environmental water to achieve environmental objectives. Releases of held water may be used to mimic the natural rise and fall of rivers (see text box), to improve water quality or flow for specific river reaches or wetlands, and even to shift water between watersheds in highly connected water systems. In addition, the

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[2] In addition, in most watersheds the Victorian water minister has set a cap on uses of water. During wet periods, flows that occur above this cap—often flood flows—are also considered to be part of the Victorian Environmental Water Reserve (see Technical Appendix B).

[3] The amount of money available through these fees varies from year to year, but is approximately AU$100m annually (see summary in 2014 audit by the Victorian Auditor-General).

[4] The amount of water held as entitlements is summarized by the Australian Government, Department of the Environment.

[5] In June 2004, the Victorian government released the "Our Water Our Future" action plan. An important component of this plan was establishing Environmental Water Reserves. The Victorian government then passed the Water (Resource Management) Act of 2005 to amend the Water Act of 1989. From 2006, the act legally recognizes the Environmental Water Reserve as the legal share of water for the environment in all Victorian rivers, streams, and groundwater systems.

[6] The Australian Commonwealth, which administers the Murray-Darling Basin Plan, also has a large environmental water portfolio managed by the Commonwealth Environmental Water Holder (CEWH) and the Living Murray Program. The CEWH works closely with the VEHW to plan and allocate environmental water.

VEHW can decide how much water to use in one year and how much to carry over in storage for release the next year. The VEWH can even decide to trade environmental water to other users.

The amount of water received by any Victorian water entitlement holder, including the environment, is based on water availability. All entitlements are made up of "water shares," which prescribe how much an entitlement holder will receive during reduced allocations. There are two classes of water shares: high-reliability shares that are principally used for high-revenue perennial crops, and low-reliability shares that usually are only available in wetter years. Currently, the environment holds approximately 26 percent of the high-reliability shares of water in Victoria (Victoria DELWP 2016).[7] During drought, low-reliability shares are allocated no water, and all high-reliability shares are reduced by an equal percentage. Thus, high-reliability shares of environmental water are treated the same as high-reliability shares for municipal and irrigation uses.

Management of the environmental water portfolio depends heavily on a functional, well-regulated water market. During the Millennium Drought, much of the initial growth of the environmental water portfolio managed by the VEHW was acquired through investments in water efficiencies. This involved making investments such as lining of irrigation canals and installation of efficient irrigation technology and purchasing water saved for the environment (Commonwealth of Australia, 2014). The volume of new water made available proved insufficient to meet environmental objectives. In recent years, the Commonwealth has purchased a significant volume of irrigation entitlements for the environment on the water market.[8] These are managed jointly with those of the VEWH. The purchase of large volumes of irrigation entitlements caused significant controversy in the MDB for many reasons, including concerns about third-party impacts on towns and regional communities, future water prices, and financial instability for irrigators and irrigation enterprises (Commonwealth of Australia 2016).[9]

In 2014–15, the VEWH accounted for roughly half of all water traded in Victoria. Most of these trades were between different sources of held environmental water, including water held by the Commonwealth, and were undertaken to move environmental water across different parts of the water system.[10] Because of its large ownership of water and involvement in water trading, the VEWH is viewed as an important and equal partner in the water entitlement system.

[7] Melbourne, the largest city in Victoria, has its own separate water system that it operates independently and is not regulated in the same way as other water-right holders.

[8] As of March 2016, the Commonwealth had purchased 345,000 acre-feet of high-reliability water entitlements and 18,000 acre-feet of low-reliability entitlements.

[9] Before its closure in 2014, the Australian National Water Commission conducted regular assessments of the social, economic and environmental impacts of water trading, including the purchase of irrigation entitlements for the environment. The last audit demonstrated local third-party impacts associated with entitlement purchases, but that overall economic and social impacts were relatively small (National Water Commission, 2012).

[10] Water trading is supported by the Victorian Water Register, a state-sponsored source for comprehensive information about water availability and use, water rights, prices and trade opportunities. Urban areas have limited access to this market, with trades principally for environmental and agricultural uses.

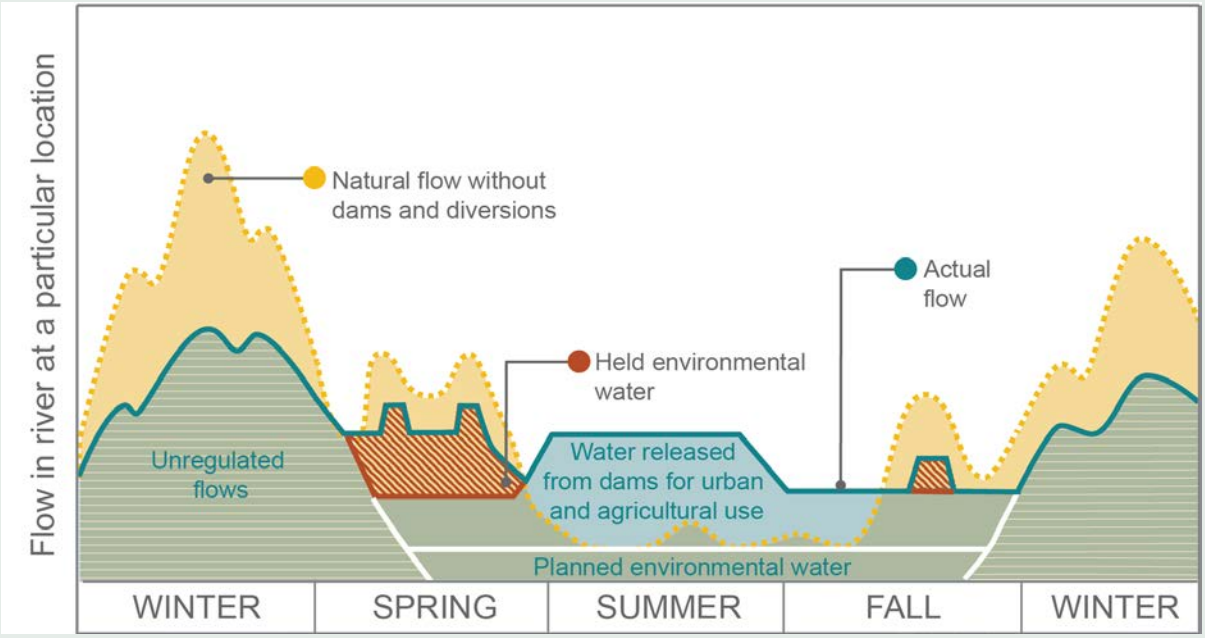
Releasing Water from Storage to Meet Multiple Needs

Water stored in Victoria's reservoirs is managed to meet urban, agricultural, and environmental demands. The Victorian Environmental Water Holder, working with catchment managers, times its release of held environmental water (i.e., stored water belonging to the environment) to improve water quality and river or floodplain habitat.

The hydrograph below illustrates how the natural flow of the river (ideal for native species) is changed by both water storage in winter and water releases and use in summer. There are three types of water releases from reservoirs:

- **Planned environmental water** to maintain minimum water quality and to keep water flowing in rivers so that releases will make it to downstream users (this is to offset high losses of water due to seepage and evaporation);
- **Water for urban and agricultural uses** (this can cause rivers to flow higher than they naturally would in the dry season), and
- **Held environmental water** to meet environmental objectives, such as pulse flows that can support riparian and floodplain vegetation or give fish migration and spawning cues.

FIGURE 2
Timing of environmental flow releases



Drought Planning

The Millennium Drought revealed significant weaknesses in preparation for managing the environmental effects of extreme water scarcity (Bond, Lake and Arthington 2008), including insufficient technical support for decision making about water allocations. Although the Millennium Drought matched the magnitude and intensity of droughts predicted for the future under climate change, there had been limited scenario testing of response options or agreed-upon priorities for allocation of water (CSIRO 2014). In essence, as in California during its current drought, Victoria's water managers were forced to make reactive, ad hoc, and often controversial environmental management decisions.

Victoria's environmental managers also faced the need for a more transparent decision-making framework. The VEWH controls significant water assets worth hundreds of millions of dollars, and the Commonwealth has water assets worth billions. They were, appropriately, subject to intense public scrutiny for their actions during drought and needed to demonstrate that they were using these assets in ways that created the best return on investment.

During the latter stages of the Millennium Drought, Victoria significantly reformed its approach to drought preparation and planning. Today, the most important planning efforts are: the Regional Sustainable Water Strategies (undertaken every 10 years), which determine whether there is sufficient water provided for the environment as planned and/or held environmental water; the Regional Waterway Management Strategies (undertaken every eight years), which set long-term objectives and targets for the environmental condition of rivers and wetlands; and the Seasonal Watering Plan (undertaken annually), which guides annual environmental water use to achieve the long-term objectives and targets for environmental conditions (Victoria DELWP 2016).[11] The latter is developed by the VEWH with extensive stakeholder input, which increases buy-in and reduces conflicts.

Setting Priorities

One of the biggest challenges during the Millennium Drought was prioritizing allocations of environmental water when there simply was not enough to meet basic objectives. Normally, the VEWH aims to achieve the greatest environmental benefit for the volume of water applied and has criteria to guide decision making. There are six criteria that environmental water managers, with input from scientists and stakeholder groups, consider in setting priorities for watering actions:

- Extent and significance of expected benefit,
- Certainty of achieving the benefit,
- Ability to provide benefits over the long-term,
- Implications of not undertaking watering actions,
- Feasibility, and
- Overall cost-effectiveness.

By systematically evaluating these six criteria, environmental water managers are better able to justify their choices for the allocation and use of environmental water to the public, which in turn reduces controversy. These criteria also help organize the development of scientific and technical support for decision making.

In the depths of the Millennium Drought, however, the situation was so dire that the "greatest environmental benefit" actually became "the avoidance of the greatest environmental loss." It was clear that the framework for

[11] To describe the condition of rivers and wetlands, the Victorian Department of Environment and Primary Industries uses an Index of Stream Condition and an Index of Wetland Condition. Targets are set for improvement in these indexes. The last systematic update of these conditions was in 2010.

decision making would need to be expanded to account for variability in conditions. As a result, environmental water managers now use a seasonally adaptive approach—described within the Seasonal Watering Plan—that sets differing environmental watering objectives depending on hydrologic conditions (Figure 3). A change in objectives in turn causes changes in the volume, location, and timing of water allocated to environmental uses. Water managers conduct extensive scenario testing to evaluate the consequences of these choices. In addition, environmental water managers have the flexibility to adjust operations depending upon unanticipated meteorological conditions, such as rainfall events and heat waves. Since these adjustments are scenario-tested in advance, this process creates greater certainty for all water users.

FIGURE 3
Examples of environmental watering objectives under different planning scenarios

Drought
Main objective: PROTECT
> Avoid critical loss
> Maintain key refuges
> Avoid catastrophic events
Dry
Main objective: MAINTAIN
> Maintain river functioning with reduced reproductive capacity
> Maintain key functions of high priority wetlands
> Manage within dry-spell tolerances
Average
Main objective: RECOVER
> Improve ecological health and resilience
> Improve recruitment opportunities for key animal and plant species
Wet to very wet
Main objective: ENHANCE
> Restore key floodplain and wetland linkages
> Enhance recruitment opportunities for key animal and plant species

SOURCE: Victorian Environmental Water Holder, 2015. Seasonal Watering Plan 2015-16: Introduction.

NOTE: The Seasonal Watering Plan sets objectives based on the amount of precipitation and the amount in storage. This allows for changing priorities that match changes in conditions.

It is important to note that priority setting is guided, but not bound, by national endangered species recovery objectives. This approach allows environmental managers to take a more ecosystem-based approach to environmental watering, focusing on maintaining ecosystem functions in critical locations that might serve a broad range of species. But it does not mean that species at imminent risk are simply allowed to go extinct. Indeed, as shown in Figure 3, the main objectives of the drought-planning scenario are prevention of species loss, maintenance of key refuges, and avoidance of catastrophic events. During extreme droughts, this clear set of priorities allows environmental managers to recognize the trade-offs involved in reducing water for one environmental objective to meet a higher-priority environmental objective.

Is the Victorian Model Successful?

Management of environmental water in Victoria has undergone significant change over the past 30 years as policy moved from providing only basic minimum flows to the acquisition of a significant and valuable portfolio of water rights requiring active management. Some of the most important—and controversial—changes occurred in 2006-10, as a response to the Millennium Drought. Most of the current water management tools were developed during this period as well. Although Victoria uses multiple monitoring and assessment programs to test

management effectiveness (see Technical Appendix A), substantive, measureable changes in environmental conditions—the ultimate test of these programs—may take decades to be realized. For this reason, it is premature to conclude that this approach is biologically successful over the long term. However, there is no doubt that its adoption avoided some serious biological losses during the drought (van Dijk et al. 2013).

Adoption of these management practices meant that environmental water managers had a robust and transparent policy framework for making decisions on the use of environmental water under all climatic conditions. It also was a policy approach that made sense to the community of agricultural and urban water users. Seasonally adaptive planning made it clear that, in times of drought when everybody is making hard water and land use decisions, environmental water managers also must make some very difficult trade-offs. The resulting changes in environmental watering priorities paralleled similar decision frameworks that irrigators were using in their businesses and that municipal water authorities were using in setting restriction policies. In addition, the changes took into account how Australian freshwater ecosystems operate in a variable climate. In a period of extreme water scarcity, when a high level of community angst and political pressure might have clouded decisions about water allocation, this approach provided sensible answers in a number of controversial areas. It may not have fully reconciled the community to the need to provide more water for the environment, but it did significantly improve the "social license" for environmental water managers to operate with the entitlements that they had been granted.

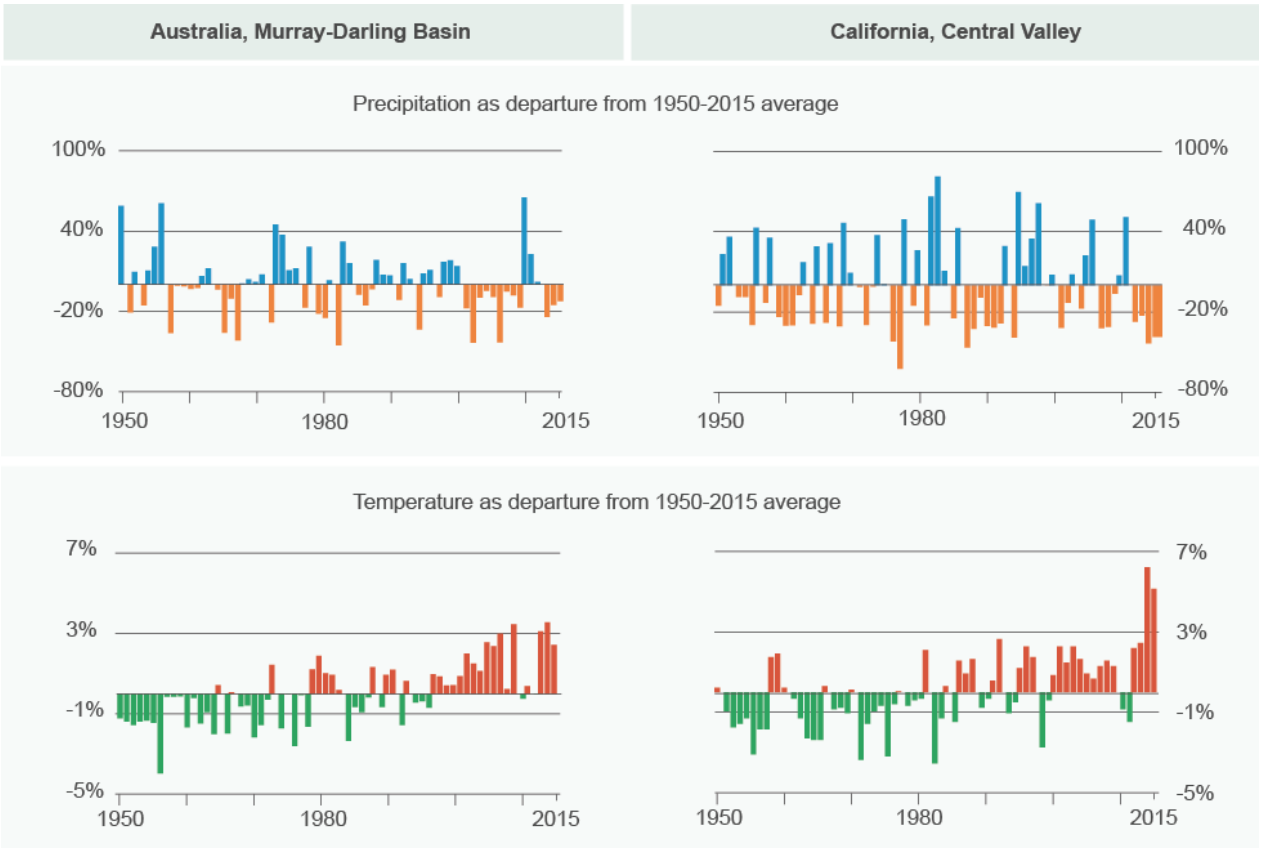
From an environmental management perspective, the Millennium Drought showed very clearly that, while there will always be scientific knowledge gaps and technical challenges, the key is to ensure that there is community understanding and therefore political support for the approaches taken. Without this, the social license to operate can quickly disappear, making both short-term management and long-term policy changes much more difficult to achieve.

Are California's Challenges Comparable?

We consider two questions in light of our research into Victoria's drought challenges: Are the two states sufficiently alike that the Australian experience is relevant to California? And are their differences likely to require different approaches to management and management institutions?

Both Victoria and California have climates that are semi-arid with cool, wet winters and dry, warm summers ideal for growing crops. Agriculture accounts for about 80 percent of the use of developed water resources in both states, with municipal and industrial supply accounting for the remaining 20 percent.[12] Both states also have highly variable precipitation with multi-year droughts that require major investments in water supply infrastructure, and each is experiencing rising temperatures. As shown in Figure 4, these similarities are most visible in comparisons of the Murray-Darling Basin and California's Central Valley.

FIGURE 4
California and Australia have both experienced multi-year droughts and rising temperatures



SOURCE: Australian Bureau of Meteorology (precipitation and temperature), National Oceanic and Atmospheric Administration (California temperature), DWR (California precipitation)
NOTE: Diagram depicts precipitation and temperature departures from average for the MDB and California's Central Valley since 1950. Note that the magnitude of precipitation deficits in California are greater than those experienced during the Millennium Drought.

[12] Based on water data from the Australian Bureau of Statistics and the California Department of Water Resources (DWR).

Both states also face similar challenges in managing freshwater-dependent ecosystems and native species. Dramatic changes over the past 150 years have altered habitat quality for native plants and animals. These changes include extensive conversion of land (usually for agriculture), dramatic alteration of the timing and quantity of flow, disconnection of river landscapes by dams and diversions, reduction of water quality, and the introduction of numerous non-native species that have proved well-adapted to these changes. These changes have led to long-term declines in freshwater-dependent native species and to the potential for numerous extinctions (Moyle et al. 2015, Pratchett, et al. 2011). And both states experience intense controversy over the proper balance between water allocations to meet environmental needs and water service for agricultural and urban uses.

These strong similarities indicate that the environmental drought management tools developed by Victoria could be broadly applicable to California. There are, however, some important differences in climate and biology that may affect the way these tools could be used. These include:

- **Duration of drought:** California's current drought came on the heels of a very wet year and is entering its fifth year. Victoria experienced sustained drought from 1997–2009, with 10 consecutive dry years from 2000–2009. The social, economic, and environmental costs associated with this level of dryness were a great impetus for change (van Djik et al. 2013). It is possible that California has not yet "suffered enough" to motivate major reforms.
- **Differences in snowpack storage:** Snowpack in California is a critical part of annual storage, but makes up only a small portion of supply in Victoria. Snowpack is a highly vulnerable source of storage during droughts, and is also likely to diminish as a result of climate warming.
- **Role of groundwater:** California has large groundwater reserves for drought management (up to 60% of supply during drought years versus 30% in average years), whereas northern Victoria has limited useable groundwater supplies (less than 20% of annual supply) due to high salinity. The large groundwater reserves in California—if managed well—improve resilience to extended droughts when surface water reserves are drawn down. Switching to groundwater during drought can reduce pressure on surface water supplies that may be needed for environmental management. Additionally, groundwater stored during wet periods can be used for environmental purposes, such as managed wetlands, or for trading.
- **Differences in surface storage:** In Victoria, surface storage relative to annual water use is twice the level of storage in California.[13] This increases flexibility in Victoria's management of environmental water. However, the high dependence on surface storage—rather than a combination of surface storage and large groundwater reserves—increases vulnerability during extended, multi-year droughts.
- **Targets of conservation:** Victoria's drought conservation efforts seek to improve habitat conditions for aquatic species, such as fish and platypus, as well as lowland riparian and floodplain plants and animals that rely on seasonal flooding.[14] In California, the focus of water management during drought is on maintaining habitat for threatened and endangered river and estuarine fishes. Additionally, most of the managed wetlands of the Central Valley, for example, are not connected to rivers, but can be served through irrigation canals.
- **Different species of concern:** Many of the at-risk Victorian species (such as the Murray Hardyhead and river red gums) have genetically diverse, distributed populations that allow for prioritization of

[13] These and other comparisons in this section are based on statistics provided by the Victorian Department of Environment and Primary Industries and the California Department of Water Resources.

[14] During the Millennium Drought, environmental managers found creative ways to deliver water to floodplain and riparian habitat without major pulse flows. This included use of earthen levees to channel flows onto floodplains as well as the use of large pumps.

conservation efforts and serve as sources for re-colonization if local extinction occurs (Davies et al. 2008, Ellis et al. 2013). Several California species, such as Delta smelt and winter-run Chinook salmon, have narrow geographic ranges and single populations, with limited potential for natural repopulation following local extinction (Moyle et al. 2015).

These differences are modest but important when considering lessons for California's environmental management. However, the management tools developed in Victoria to address the specific needs of the Murray-Darling Basin are not overly specialized and therefore could be broadly applicable to California.

Four Key Lessons for California

The Victorian institutions that have evolved to address environmental water management are, like the climate and biology of their state, quite similar to California. Water in both states is a public-trust resource to be managed by the state for beneficial uses, including environmental health. State and federal agencies develop environmental objectives, set and enforce regulatory standards, manage water rights and environmental water, and develop scientific support for decision making (see Technical Appendices A and B). In principle, the objectives and institutions of the two states are broadly the same. In practice, however, there are significant differences. We highlight four key lessons that can inform potential reforms for California as it grapples with ways to improve environmental water management and conserve native species.

Lesson 1: Planning Matters

The Millennium Drought changed how Victoria prepares for and responds to drought. Victoria's multiple planning processes now address three key requirements for drought management:

- Pre-drought efforts to improve species' population resilience;
- Water allocation priorities to reduce harm during drought (including emergency responses), and
- Actions to recover species following drought.

The robust planning framework that Victoria developed—including scenario testing to anticipate actions during drought—is arguably the most important policy innovation to emerge from the Millennium Drought.

California does not have biodiversity plans that specifically address species' drought resilience, response and recovery (Hanak et al. 2015). Although the state has made great progress in monitoring at-risk species during the latest drought and has developed long-range plans to improve the resilience of a few species, it relies principally on reactive prioritization and decision making during drought emergencies.[15]

Additionally, one of the key lessons of the Millennium Drought was the value of developing community understanding of approaches taken to manage environmental water, principally through the planning process. This was essential to building political support—or, at a minimum, reducing opposition—for potentially controversial actions. California invests heavily in stakeholder outreach and public hearings, as well as extensive (and often costly) environmental documentation. However, with some notable exceptions (e.g., the recent negotiated Klamath dam removal agreements), the state and federal government have been unable to match Victoria's level of community understanding when it comes to environmental water management. This makes it difficult to take significant action in a timely manner. Given the scale and complexity of California's challenges, it is possible (though not certain) that more transparent and systematic planning based on the Victorian model may prove useful here.

***Key Takeaway**: Improved environmental drought planning can strengthen the drought resilience of native species and reduce conflict during drought.*

[15] The California Department of Fish and Wildlife is responsible for drought response to protect native species. An online summary of the agency's Drought Response Projects reveals that most efforts were on species rescues or monitoring actions. Relatively few involve plans to significantly improve drought resilience.

Lesson 2: State and Federal Partnerships Are Essential

Both California and Victoria manage water along with their respective federal governments. In Australia, the response of the Commonwealth to the Millennium Drought was substantial and transformative. This included reforming key federal laws to enable better management and making multi-billion dollar investments to purchase irrigation entitlements to improve environmental flows. Today, the Commonwealth is a key partner with Victoria in planning for drought, as well as in building and managing the environmental water portfolio.

Recent federal investment in improving drought preparedness and response in California—beyond its existing water supply operations and regulatory roles—has been modest by comparison to Australia (Mount et al. 2016). There have been significant improvements in federal-state coordination, particularly during the drought emergency. But federal spending to enhance environmental flows has been limited in scope, focused mainly on acquiring some temporary supplies for wetlands. During the latest drought, most federal activity has sought to improve agricultural and urban supplies, including investments in water-use efficiency and multiple petitions to state regulators to relax environmental standards to allow for increased water diversions (Hanak et al. 2015, Gray et al. 2015). Current federal drought legislation under consideration does not address the environment.

Key Takeaway: *Federal support, through policies and funding, can make a major difference in improving environmental drought resilience and responding to drought emergencies.*

Lesson 3: A Water Right for the Environment

Victoria and the Commonwealth explicitly recognize that the environment is a lawful user of water and entitled to a water right. Held environmental water—that portion of stored water granted to the environment under its entitlement—is critical to meeting environmental objectives during drought. Held environmental water managed by an environmental water holder can be flexibly allocated to meet objectives, including transfers between local watersheds and release of flows timed to meet biological needs. Managing and increasing the amount of held environmental water requires reliable funding (e.g., from a volumetric surcharge on water use) and water trading (both short-term and long-term). This trading is supported by a sophisticated, government-run registry that tracks water availability, price, and use.

California also has water dedicated to environmental uses. For example, the federal Central Valley Project Improvement Act of 1992 requires the US Bureau of Reclamation to allocate 800,000 acre-feet of water to improve fisheries, water quality, and wetlands in the Sacramento-San Joaquin River and Delta watershed.[16] This environmental allocation was augmented for several years by an Environmental Water Account operated by the California Department of Water Resources that funded temporary water purchases for environmental needs.[17] California also has a small but growing number of water rights that have been permanently dedicated to improving instream flows (Szeptcki et al. 2015).[18] Indeed, short- and long-term water trading is playing an

[16] The total amount of water allocated annually varies, depending on water year type, with the legally mandated environmental allocation reduced to 600,000 in dry years (CVPIA 1992). Indeed, the actual amount of environmental water is sometimes much less. For example, in water year 2015, the Bureau of Reclamation released only 200,000 acre-feet for environmental uses. Moreover, in all types of water years, water initially allocated to the environment is then re-diverted downstream and used for agricultural and municipal supply (US Fish and Wildlife Service and US Bureau of Reclamation 2016).

[17] There have been large-scale experiments in water trading to meet environmental needs. Most prominent of these was the CALFED Environmental Water Account (EWA). The CALFED 2000 Record of Decision established the EWA to reduce the impacts of Central Valley Project and State Water Project export pumping from the Sacramento and San Joaquin Delta (CALFED 2000). Temporary purchases of water from willing sellers were used either to supplement flows within the Delta or to find alternative sources for project users. The goal was to allocate environmental water above regulatory baseline flows to improve conditions for at-risk native fishes. The amount of water purchased for the environment declined after 2007. The last long-term acquisition was for 60,000 acre-feet per year from 2008-15 from the Yuba County Water Agency under the Yuba Accord Water Purchase Agreement. There are also ongoing efforts, such as those of the US Bureau of Reclamation to sell, recover, exchange, or bank water that is stored but not used for restoration of the San Joaquin River. The description of the management plan for these unreleased restoration flows is described here.

[18] The usefulness of these rights during drought depends on their volume and seniority (Technical Appendix B).

increasing role in environmental management, particularly in some small watersheds (Hanak and Stryjewski 2014, SWIFT 2016). Finally, in 2014, Californians voted to allocate $200 million in Proposition 1 bond funds to enable the Wildlife Conservation Board to acquire long-term supplies for the environment. Distribution of funds for these purchases is still in its earliest stages.

These multiple efforts to secure and manage water for the environment in California suffer from several disadvantages in comparison to Victoria. First, water dedicated to the environment through regulatory processes cannot be managed as flexibly as environmental water rights.[19] Second, the total volume of environmental water trading is modest in size (Hanak and Stryjewski 2014; Hanak and Jezdimirovic 2016); and, due to funding constraints, tends to go down during drought when this water is most needed. Third, California has an inefficient water market that lacks a functional water registry—a tool that can facilitate and track trading (Gray et al. 2015). This greatly limits the ability to trade water for the environment, even if it is available. Fourth, California has no equivalent to the Victoria Environmental Water Holder to organize and manage environmental water to meet planned objectives.[20] Finally, the environment is one of California's long-standing "fiscal orphans," with no reliable source of funding beyond periodic infusions of bond funds (Hanak et al. 2014).

Key Takeaway: *Granting the environment a high-priority water right (or its equivalent)—supported by a robust water market and reliably funded, coordinated management—can help reduce uncertainty and increase flexibility for environmental drought management.*[21]

Lesson 4: The Environment as an Equal Priority

National and state level reforms in Australia before and during the Millennium Drought elevated the environment to the status of an equal priority with urban and agricultural uses. Planning efforts integrated the environment into all aspects of water management, setting broad objectives for maintaining healthy ecosystems and preparing for, and responding to, drought. The environment was granted a water right, giving the Victoria Environmental Water Holder and other environmental water managers the resources to build and manage an extensive water portfolio. In this way, the environment became a key stakeholder in water management with an equal "seat at the table" in negotiations, while also becoming a partner in constructing solutions. Moreover, the structure of this right—i.e., with cuts shared equally among holders of high priority shares, including the environment—reduced the perception that the burdens of drought were not shared equally.

California has made important strides on integrating the environment into its water planning and operations. Negotiated agreements, such as the Lower Yuba River Accord, have shown promise in improving the allocation of water for environmental purposes (especially during drought), while still meeting demands of other water users.[22] More generally, the Delta Reform Act of 2009 made it state policy to manage and allocate the waters of the Sacramento-San Joaquin and Delta ecosystem for the "co-equal" goals of water supply reliability and ecosystem health.[23]

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[19] For instance, during the latest drought, it would have been helpful if water allocated to wildlife refuges under the CVPIA could have been traded, to help get limited supplies to places along the Pacific Flyway where water was most needed.

[20] The exception may be environmental water trusts in small catchments that assume this role (SWIFT 2016).

[21] The concept of an "Environmental Water Budget" for California that functions like Victorian held environmental water is explored in Gray et al. (2015).

[22] The Lower Yuba River Accord is a negotiated settlement between diverse agricultural, urban and environmental interests as well as state and federal regulators. It relies on integrated management of surface water and groundwater to improve environmental conditions in the Yuba River and in the Delta, meet local and regional water supplies, and manage flood risk.

[23] According to the California Water Code §85054, "Coequal goals means the two goals of providing a more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. The coequal goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place."

Yet despite these advances in policy, environmental objectives remain principally focused on meeting minimum regulatory requirements under the state and federal water quality and endangered species laws, rather than to improve overall environmental conditions (Hanak et al. 2011). Conceptually, this approach may be more protective of at-risk native species than the more flexible, ecosystem-based approach taken by Victoria, because it makes avoidance of extinction the highest environmental priority.[24] But it also creates the perception that the environment is simply a constraint, rather than an integrated priority in water management.[25]

Key Takeaway: *Fully integrating the environment into water management—including defining environmental protection and restoration as a priority and allocating resources to environmental watering—can improve drought resilience and decrease controversy.*

[24] In California, both federal and state Endangered Species Acts prohibit the unauthorized taking of listed species, and the federal law precludes any federal (or federally authorized or funded) action that would place a protected species in jeopardy of extinction or adversely modify its critical habitat. Although Victoria has a strong policy of avoiding risk of extinction and of causing harm to endangered species during drought, nothing in state or national law categorically prohibits taking of, or jeopardy to, such species (Technical Appendix B).

[25] This perception that the environment is a burden on efforts to maximize urban and agricultural uses of water is not unique to California. It is ingrained in the approach to western US water policy in general and is part of federal water policy that seeks to "wring as much water from the system without breaking laws" (Mount et al. 2016).

Conclusion

The state of Victoria, along with the Commonwealth of Australia, enacted sweeping reforms that improved the effectiveness and acceptance of allocation of water to the environment. California, now in its fifth year of drought and with similar biological, political, and social challenges, can learn from Victoria's policy reforms.

Four general lessons from Victoria's Millennium Drought experience are of value to California:

- Planning for drought, rather than reacting to drought, can improve environmental management and reduce conflict. California lacks reliable and accepted environmental drought plans to protect native species, to build resilience during normal and wet years, and to set priorities during times of extreme scarcity.
- Strong state and federal partnerships are vital to drought preparation and response. Although federal-state coordination and communication has improved, the federal government—despite its key responsibilities in regulating and providing water resources—has not played a significant role in anticipating or ameliorating the effects of drought on California's environment.
- An environmental water right, as part of a flexibly managed portfolio of environmental water, can be effective in adapting to drought. Although California has some water allocated to the environment, the volumes are still relatively small and the supplies cannot be flexibly managed, limiting their impact. Efforts to acquire significant permanent supplies for environmental uses have been limited by a lack of funding.
- Treating environmental water as equal in status to that of other uses would help integrate environmental protection and enhancement into all phases of water management. This in turn would increase the responsiveness, flexibility, and effectiveness of California's long-term "environmental watering" programs and better enable the state to achieve its policy of "co-equal" goals for water supply reliability and ecosystem health.

One of the most distinctive differences between California and Victoria is the comparative capacity for resolving conflict over environmental water. Although policy reforms during the Millennium Drought proved highly controversial and difficult to enact, Victorians managed to complete a suite of changes that have improved environmental water management and addressed key issues of drought preparation, drought response, and drought recovery. For whatever reason—social, legal, or political—Californians have found it difficult to tackle this issue in a productive way.

California has made some important advances in environmental water management during the current drought, including enacting historic legislation to reform groundwater management, developing new standards for environmental flows in a few basins, and allocating bond funds to purchase water rights for the environment. But much more needs to be done to improve drought resilience and to reduce conflict over environmental water allocations for future droughts. As California tackles these improvements, the planning and management adaptations developed by Victoria during the Millennium Drought can serve as a useful guide.

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